AD-A183 743 EVALUATION OF GREASE MANAGEMENT ALTERNATIVES FOR ARMY WASTEWATER COLLECTI..(U) CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL J T BANDY ET AL. 1/1

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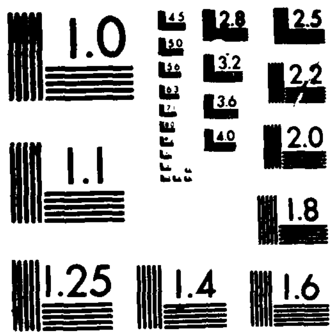

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AD-A183 743

Evaluation of Grease Management Alternatives for Army Wastewater Collection and Treatment Systems

by
John T. Bandy
Richard M. Marlatt
Lynn E. Lang
Calvin P. C. Poon
Kenneth Skov
Temkar M. Prakash

Research was conducted by the U.S. Army Construction Engineering Research Laboratory (USA-CERL) to: (1) determine the nature and extent of grease and oil problems at fixed Army installations, identify the installations' current oil and grease control practices, and evaluate these methods' effectiveness and cost, (2) identify, from published information, commercially available grease and oil control methods (including chemical and biological additives) and establish their properties and applications, (3) collect and evaluate case histories, and (4) provide guidance for determining whether use of an alternative method would be cost-effective at military installations.

A survey determined that over two-thirds of the installations responding experienced problems with grease and oil accumulation. Over 80 percent had problems at least monthly. Army-wide, thousands of dollars are spent each year on grease management. Mechanical cleaning methods are labor-intensive and provide only a short-term solution; chemical cleaners are expensive and can be dangerous to treatment plant workers and the environment.

Commercially available biological additives for grease and oil control are identified and described. In addition, case histories are evaluated. Results indicate that the decision to use biological additives in controlling oil and grease accumulation should be made on a case-by-case basis. A procedure is proposed for helping installations calculate grease management costs and determine if use of an alternative technology would be cost-effective.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

AD-A183743

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date Jun 30, 1986

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): USA-CERL TR N-87/15	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION: U.S. Army Construction Engr Research Laboratory — 6b OFFICE SYMBOL (If applicable): USA-CERL	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State, and ZIP Code): P.O. Box 4005, Champaign, IL 61820-1305	7b ADDRESS (City, State, and ZIP Code)
8a NAME OF FUNDING/SPONSORING ORGANIZATION: HQUSACE — 8b OFFICE SYMBOL (If applicable): DAEN-ZCF-U	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: FAD 2-2283, dated 30 March 1983
8c ADDRESS (City, State, and ZIP Code): 20 Massachusetts Ave., N.W., Washington, D.C. 20314-1000	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11 TITLE (Include Security Classification)
Evaluation of Grease Management Alternatives for Army Wastewater Collection and Treatment Systems (Unclassified)

12 PERSONAL AUTHOR(S)
Bandy, John T.; Marlatt, Richard M.; Lang, Lynn E.; Poon, Calvin P.C.; (Cont'd)

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM ____ TO ____	5-87	44

16 SUPPLEMENTARY NOTATION
Copies are available from the National Technical Information Service
Springfield, VA 22161

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	wastewater, greases
24	04		oil wastes, waste treatment

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

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20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL: D. Finney	22b TELEPHONE (Include Area Code): (217) 352-6511 ext 389 — 22c OFFICE SYMBOL: CECER-IMT

DD FORM 1473, 84 MAR
83 APR edition may be used until exhausted.
All other editions are obsolete.

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Skov, Kenneth; Prakash, Temkar M.

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Commercially available biological additives for grease and oil control are identified and described. In addition, case histories are evaluated. Results indicate that the decision to use biological additives in controlling oil and grease accumulation should be made on a case-by-case basis. A procedure is proposed for helping installations calculate grease management costs and determine if use of an alternative technology would be cost-effective. Keywords: waste treatment; pollution abatement; waste management

FOREWORD

This research was conducted under a reimbursable work unit for Headquarters, U.S. Army Corps of Engineers (HQUSACE) under Funding Authority Document (FAD) 2-2283, dated 30 March 1983. The work was performed by the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (USA-CERL), in conjunction with the University of Rhode Island. The HQUSACE Technical Monitor was T. Wash, DAEN-ZCF-U.

C. P. C. Poon and K. Skov are with the University of Rhode Island. Dr. R. K. Jain is Chief, EN.

COL N. C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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TABLES

EVALUATION OF GREASE MANAGEMENT ALTERNATIVES FOR ARMY WASTEWATER COLLECTION AND TREATMENT SYSTEMS

1 INTRODUCTION

Background

Each year the Army spends thousands of dollars on grease and oil removal at fixed installations. Grease traps from mess halls and motor pools are the two main areas where grease accumulates. In addition, grease and oil can build up in the wastewater collection and treatment systems and produce adverse effects such as blockage or flow restriction in sewer lines, fouling of pumping station components, blocking of treatment plant screens, poor settling in clarifiers, and interference with biological wastewater treatment processes. Besides these impacts, grease and oil create problems with esthetics, odor, and insects.

Accumulated grease and oil are usually removed mechanically at Army posts (e.g., pumping out grease traps, cleaning sewer lines). However, mechanical methods are labor-intensive and do not prevent grease and oil buildup. Easier, more cost-effective methods are needed for controlling and removing grease and oil from sewerage systems. Current technology, including chemical and biological additives now on the market, should be evaluated as alternatives to mechanical cleanout methods.

Objectives

The objectives of this work were to: (1) determine the nature and extent of grease and oil problems at fixed Army installations, identify the installations' current oil and grease control practices, and evaluate these methods' effectiveness and cost; (2) identify, from published information, commercially available grease and oil control methods (including chemical and biological additives) and establish their properties and applications; (3) collect and evaluate case histories; and (4) provide lessons learned and guidance for deciding if any of the alternative methods would be more cost-effective than mechanical cleaning at military installations.

Approach

A letter survey was conducted during 1983 to examine the extent and nature of grease and oil problems at fixed Army installations. Published information on the use and types of chemical and biological additives as well as mechanical methods for grease and oil removal was then reviewed. Applications of the additives were identified and evaluated as case histories.

Finally, a method was developed to help installations calculate costs related to grease/oil removal and to determine if an alternative method such as an additive would be cost-effective.

Scope

Information in this report applies to facility engineers and other personnel concerned with grease and oil control and removal from traps, sewer lines, and wastewater treatment facilities at fixed Army installations. The guidance is intended to identify the types of biological and chemical additives available for grease management along with their advantages and disadvantages compared to mechanical control methods.

Most installations handle oil and grease in common facilities and have effluent limits for wastewater treatment stated in terms of "oil and grease" as a single parameter. For this reason, control practices and costs for both are included in this study.

2 SURVEY RESULTS AND ANALYSIS

A survey form on grease and oil problems at Army facilities was distributed to 39 U.S. Army installations in August 1983. The survey asked for the location of grease and oil buildup, frequency of occurrence, methods used to deal with problems, and other general information about grease and oil accumulation. All 39 Army facilities completed and returned the survey. Twenty-six, or 67 percent, of the facilities reported having grease and/or oil problems. The survey data were analyzed to develop a summary of grease and oil problems at Army facilities (Tables 1 through 9).

Table 1 indicates that the two primary locations where grease and oil problems occur are in grease traps, with 46 percent of the facilities reporting problems, and motor pools, where 62 percent reported problems. The grease traps receive mess hall (kitchen) wastes such as vegetable oils and animal fats. The motor pool problem is due to waste motor oils and washrack drainage (Table 2). Tables 3 and 4 show that 71 percent of the reporting installations discharge motor pool and washrack drainage to sanitary sewers and that 42 percent of the responding facilities have oil and grease included in their National Pollution Discharge (NPDES) permit for the wastewater treatment facilities.

Table 5 shows that over half (56 percent) of the Army facilities that reported frequency of problems have these problems on a weekly basis. In addition, 80 percent of the facilities reporting have problems at least once per month.

The Army removes accumulated grease almost exclusively by mechanical cleaning methods (Table 6). Eighty-one percent of the facilities reported using mechanical cleaners such as sewer rodders, cable machines, and water jets. Only two facilities, or 8 percent, reported trying biological additives and two reported using chemical additives. (It was later learned that two installations have field-tested biological additives for grease removal; these studies are discussed in Chapter 3.)

Tables 7 and 8 show the expenses Army facilities incur for grease and oil removal. Table 7 is notable because it illustrates the difficulty installations have in compiling consistent information on grease removal costs. Forty-six percent of the responding facilities reported costs under $1000 whereas 23 percent reported costs at a much higher range--from $30,000 to $50,000. At first, it might appear that there is wide variance either in the scope of the grease problem or in the cost of solving individual problems; however, both situations are unlikely. It is more likely that different *types* of costs are being documented rather than actual cost differences occurring. In other words, these costs probably reflect significant differences in the cost basis rather than differences in the size of the problem. For example, one difference in cost basis is no doubt due to the high degree of arbitrary maintenance activity provided for oil and grease removal at each facility.

Table 8 further illustrates the reporting discrepancies. Base population and sewage treatment plant (STP) flow cannot fully account for the variations reported in grease removal costs. If so, a pattern would be expected in which costs increase with population and flow; however, this pattern does not always occur. For example, Anniston Army Depot, AL, with 49,020 residents and 0.4-mgd STP, reported $50,000 for grease removal; Fort George Meade, MO, with 49,760 residents and 2.6-mgd STP, spent only $1250. Clearly, population size and STP flow alone do not explain the wide variation in removal costs. Another factor that varies is the labor used to remove grease and maintain the sewage system (Table 9). Some installations use their own personnel, whereas others contract this work to outside agencies.

These survey results identified a need for consistency in compiling costs for oil and grease removal. Therefore, guidance was developed and is discussed in Chapter 4. Installations using this guidance for future reporting should show much less variance in cost.

Table 1

Locations of Grease and Oil Problems at Army Facilities

Location	No. Facilities Reporting	Percent Response*
Sewage treatment plant	7	27
Grease traps	12	46
Sewer lines	7	27
Housing laterals	4	15
Motor pools	16	62
Combination of two or more locations	8	31

*Percentage based on 26 facilities that reported grease and oil problems.

Table 2

Sources of Grease and Oil at Army Facilities

Source	No. Facilities Reporting	Percent Response*
Mess halls	18	50
Hospitals	4	11
Schools	2	6
Motor pools	25	69

*Percentage based on 36 facilities that reported sources of grease and oil.

Table 3

Discharge of Motor Pool and Wash Rack Drainage

Discharge Receptor	No. Facilities Reporting	Percent Response*
Sanitary sewer	27	71
Storm sewer	11	29

*Percentage based on 38 facilities that reported discharge practices.

Table 4

NPDES Permit Requirements at Army Facilities (Oil and Grease)

NPDES Permit Requirement	No. Facilities Reporting	Percent Response*
Oil and grease included	13	42
Oil and grease not included	18	58

*Percentage based on 31 facilities answering the question.

Table 5

Frequency of Oil and Grease Problems at Army Facilities

Frequency	No. Facilities Reporting	Percent Response*
Weekly	14	56
Monthly	6	24
A few times/yr	3	12
Once/yr	2	8

*Percentage based on 25 facilities that reported frequency of grease and oil problems.

Table 6

Current Methods Army Facilities Use to Deal With Oil and Grease Problems

Method Used	No. Facilities Reporting	Percent Response*
Biological additives	2	8
Chemical additives	2	8
Mechanical cleaning	21	81
Manual cleaning	1	4

*Percentage based on 26 facilities that reported methods used.

Table 7

Approximate Yearly Cost for Grease Removal at Army Facilities

Cost ($)*	No. Facilities Reporting	Percent Response**
1 - 1,000	6	46
1,001 - 5,000	3	23
5,001 - 15,000	1	8
15,001 - 30,000	0	0
30,001 - 50,000	3	23

*1983 dollars.
**Percentage based on 13 facilities that reported cost data.

Table 8

Cost Data for Grease and Oil Removal in Relation to Facility, Population, and Sewage Treatment Plant Flow

Army Facility	Residents	Nonresidents	Avg Daily Flow of STP (MGD)	Yearly Cost for Grease Removal ($)*	Yearly Cost for Oil Removal ($)*
Anniston Army Depot, AL	20	49,000	0.4	50,000	
Badger AAP	350	-	0.04	-	4,000
Fort Benning, GA	24,000	7,000	3.0 & 6.0	-	
Carlisle Barracks, PA	500	5,500	0.25	NA**	NA**
Fort Carson, CO	22,500	2,000	2 - 3	1,047	10,792
Cornhusker AAP	37	193	-	60	
Fort Devens, MA	16,469	10,395	1 - 7	5,000	
Fort Gillem, GA	18,604	14,390	2.4	6,000	25,000
Fort Gordon, GA	16,000	25,000	1.5		

*1983 dollars.
**Not applicable since this installation earns a profit by selling waste grease and oil.

Table 8 (Cont'd)

Army Facility	Residents	Nonresidents	Avg Daily Flow of STP (MGD)	Yearly Cost for Grease Removal ($)*	Yearly Cost for Oil Removal ($)*
Fort Hamilton, NY	1,452	1,758	-	2,000	-
Indiana AAP	259	1,600	0.145	264	132
Fort Indiantown Gap, PA	-	-	0.8	-	1,000
Iowa AAP1	128	900	0.55	0	500
Jefferson Proving Ground, IN	40	40	0.183	600	-
Letterkenny Army Depot, PA	120	5,500	0.041	70	
Lone Star AAP, TX	1,500	-	-	NA	20,000
Fort McCoy, WI	100	6,500	0.6	-	-
Fort George Meade, MO	25,350	24,410	2.6	800	450
Navajo Army Depot, AZ	120	-	0.1	-	
Newport AAP	325	-	0.2	-	-
Oakland Army Base, CA	3,390	290	0.13	5,400	-
Pine Bluff Arsenal, AR	150	140	0.3	NA	NA
Fort Polk, LA	15,000	3,000	3.0	-	-
Ravenna AAP, OH	62	225	0.39	192	35
Red River Army Depot, TX	125	5,500	0.8	600	600
Fort Riley, KS	17,800	-	2.5	34,800	35,000
Fort Richardson, AK	1,800	8,800	-	46,000	40,000
Rocky Mountain Arsenal, UT	10	300	0.03	-	-
Fort Rucker, AL	19,000	-	1.4	-	-
Seneca Army Depot, NY	1,500	-	0.35		
Sharpe Army Depot, CA	100	1,400	0.112	2,000	3,000
Tooele Army Depot, UT	70	4,000	-	-	
Fort McClellan, AL	-	-	-	-	1,250
New Cumberland Army Depot, PA	-	-	0.2	600	0
Volunteer AAP, TN	160	-	0.1	-	100

*1983 dollars.
**Not applicable since this installation earns a profit by selling waste grease and oil.

Table 9

Responsibility for Grease and Oil Removal at Army Facilities

Responsible Party	No. Facilities Reporting	Percent Response*
Outside contractors	22	59
Army personnel	15	41

*Percentage based on 37 facilities that answered the question.

3 GREASE-RELATED PROBLEMS AND ALTERNATIVE MANAGEMENT METHODS

Grease Accumulation and Related Problems

The term "grease" as commonly used in wastewater treatment includes fats, oils, waxes, free fatty acids, and other related constituents. The terms "grease," "fat," and "oil" are used rather loosely in the language of wastewater treatment because they do not correspond to a definite compound, but are made up of groups of compounds with common properties. Grease, fat, and oil are compounds (esters) of alcohol or glycerol (glycerin) and fatty acids. Fats and oils are the third major component of foods. They are found in meats, vegetables, seeds, nuts, in the germinal area of cereals, and in certain fruits. They are contributed to domestic sewage as discharged butter, margarine, lard, and feces as well as the sources mentioned above. Installation of a garbage disposal in a home increases the wastewater grease content by approximately 35 percent. Greases are among the more stable organic compounds and generally are not easily degraded by bacteria. Grease usually floats on wastewater, although a portion is carried into the sludge on settling solids. Grease adheres to surfaces, interferes with biological action in waste treatment processes, and causes many maintenance difficulties. If grease is not removed through waste treatment processes, it can interfere with biological life in surface waters.

A coating of grease and other organic materials builds up on the inner surfaces of grease traps and sewer lines, thus restricting effective capacity. Sometimes flow is completely blocked by grease buildup. Another serious problem caused by grease buildup is fouling of the level control system, bubblers, or floats in a pumping station. Grease in sewage also can affect operations in a wastewater treatment plant. Preliminary treatment problems include clogging of screens and comminuters and poor grit separation. A high grease content in the wastewater can create poor settling in the primary settling tanks. If grease enters the secondary treatment unit, it will cause grease balls and poor biochemical oxygen demand (BOD) reduction as well as various other operational problems.

Grease can produce esthetic and odor problems and reduce digester capacity so much that inadequate digestion occurs. Grease in digesters also raises the heat requirement for maintaining the proper temperature for normal operation.

Installation food preparation facilities use large amounts of cooking oil and fats in food production. Also, much lipid waste is generated in processing meat and meat products. Hot water used in dishwashing and various other cleaning tasks liquifies most grease discharged into the sewage system. In the sewer system, the water cools and the grease congeals, causing sewer line deposits that restrict and eventually block normal flow. Grease traps (interceptors) have been installed in food preparation facilities to catch the grease and minimize blockage and sewage treatment plant problems; however, problems related to grease buildup still occur when the interceptors are not kept clean or when they do not function properly.[1]

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[1] *Disposal of Waste Grease Generated From Dining Facilities*, U.S. Army ID #SRN14-88323-023 (1981).

Grease Management Methods

The literature was surveyed to determine alternative methods for grease management in wastewater collection and treatment systems. Included in the literature survey were different types of additives--chemicals such as acids, alkalis, solvents, bacterial cultures, and enzymes; mechanical methods used in cleaning sewer systems (sewer rodders, cable machines, water jets); and application methods for sewer-cleaning machines and additives.

Mechanical Cleaning

There are three different ways of mechanically cleaning grease from sewer lines. The first is to use a sewer rodder which is marketed in two different designs. One is the continuous rodder which is shaped like a large snake; it is a continuous metal bar that operates with a spinning motion which usually is provided by an electric motor or gasoline-powered engine. The other type of rodder is called "sectional" because it is assembled in short sections. One section is fed into the sewer line and then another section is attached and this process is repeated until the blockage clears. Various types of blades or heads attached to the end of the rodder are designed to cut or push through the grease and grit deposits. Examples are augers, cutters, corkscrews, rootsaws, and spearheads.

The second mechanical method used to clear grease from sewer lines is the cable machine. This device is similar to the rodder, but instead of inflexible rods, it uses a flexible cable to drive the various blades and cutters attached to its end. It is also driven by an electric motor or gasoline engine and has a rotating and forward motion to dislodge and break up grease and grit in the pipeline. The main difference between the cable machine and the rodder appears to be that the cable machine has more flexibility for following a pipeline; the rodder does not bend very much. Both of these devices are sold in various sizes. Smaller rodders and cable machines are easily transported and are suitable for use in small-diameter pipes, such as household plumbing. Large truck- or trailer-mounted models are available for use by municipalities for cleaning large-diameter sewer lines. Many other intermediate-sized rodders and cable machines also are available.

The third type of sewer-cleaning method is water-jetting. The water jet usually is truck- or trailer-mounted because of its large size. It operates via high-pressure water jets striking and breaking up grease in the sewer lines. Components of the water jet include a high-pressure pump which pumps water at high pressure into a hose and then into the jet nozzle attached to the end of the hose. The jet nozzle propels itself through a pipeline with backward facing jets while its forward facing jets break up the grease and grit deposits in its path.

Combination water jets/vacuum machines are also on the market. This method not only breaks up the grease and grit with the water jet but also vacuums it out of the sewer line so as not to clog the line further downstream.

Although mechanical methods of cleaning sewer lines are the ones used most commonly, no published articles discussing these methods were found. The only source of information on mechanical cleaning methods and equipment was manufacturers and actual system users. The manufacturers offer booklets and brochures describing their products.

Sewer System Additives

The literature describes several cases of success in using various products to remove and control grease accumulation. Most articles deal with bacterial and enzymatic additives applied to grease traps, sewer lines, treatment plants, and various other systems.[2]

Chemical additives such as harsh caustics, strong acids, and solvents often have proven effective in cleaning grease traps and sewer lines. However, these techniques can be unpleasant, expensive, and sometimes hazardous to sewer workers. New ways of cleaning grease traps and sewer lines have been developed recently. Enzymes, bacteria cultures, nutrients, and mixtures of the three have been shown to remove grease effectively. Unlike the chemicals, these biological additives help digest and liquify the grease to simple endproducts.

Chemical Additives. Chemical additives for cleaning clogged drains and sewer lines often have been used for acute blockages in domestic sewage disposal systems. These chemicals are either a very strong acid or alkali product. The product most commonly used is sodium hydroxide, which is especially effective in cleaning blocked household drains. It reacts chemically with fat, causing saponification which results in a water-soluble endproduct (soap) and the liberation of heat. The heat produced in the chemical reaction is an important factor in solubilizing and liquifying the solidified grease. Strong acids work in much the same way, except that the chemical reaction is with suspended carbohydrates and proteins with the resulting heat serving to liquify the fat.

Both acids and alkalis are extremely corrosive to most metals and can be very dangerous to sewer workers if proper precautions are not taken. The heat liberated by the chemical reaction has caused collapse and other damage to polyvinyl chloride (PVC) sewer lines. Neither type of chemical is used in large, commercial-type facilities to

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[2]"Bacteria Helps Clear the Air," *Water and Waste Engineering*, Vol 16, No. 10 (October 1979), p 18; "Bacteria Keeps Drains Open at Las Vegas Airport," *Las Vegas Sun* (1 March 1979); "Bacteria Solve Problems Created by Prisoners," *Public Works Magazine* (June 1982); A. C. Bryan, "How Enzymes Improve Sludge Digestion," *Public Works*, Vol 83 (December 1952), p 69; C. A. Caswell, "The Use of Bacterial Cultures to Control Oil From a Bulk Oil Handling Terminal," presented at the 26th Purdue Industrial Wastewater Conference (1971); "Clean That Sewer System With Bugs," *Environmental Science and Technology* (October 1979); "Dried Bacteria Cultures Effective Grease Removers," *Water Engineering and Management* (March 1983); C. Gardner, "Bacterial Supplementation Aids Wastewater Treatment," *Public Works Magazine* (March 1980); "Grease-Eating Bacteria Unclog Sewers," *Popular Science* (July 1983); "Grease Eaters Clear Sewers," *Engineering News Record* (September 1982); R. A. Kirkup and L. R. Nelson, "City Fights Grease and Odor Problems in Sewer System," *Public Works Magazine* (October 1977); A. D. McPhee and A. T. Geyer, *Aeration, Bottom Turbulence, and Bacteriological Studies of Naval Ship Sewage Collection, Holding, and Transfer Tanks*, Report 77-0043 (Naval Ship Engineering Center, April 1977); "Prison Diet Includes Bio-Culture Additives," *American City and County Magazine* (September 1982); R. R. Robinson, "Enzymes Give Good Results in Sewage Treatment Plans," *Public Works*, Vol 85 (1954), p 116; *The Queen Mary: A Report on the Use of DBC Plus Dried Bacteria Cultures* (Cultured Chemical Division, Bower Industries, Inc., September 1971).

prevent grease blockages in sewers, grease interceptors, or sewage treatment plants. Acid and alkali use is limited to the treatment of acute blockages in domestic sewer and drain lines.[3]

Some solvents, however, are being marketed for preventive maintenance in sewer lines and grease interceptors at large, commercial facilities. These products are claimed to remove grease deposits without upsetting the biological environment in a septic tank or sewage treatment plant when used as directed. The manufacturers' literature advertises these products as "chemical grease removers" but does not give the chemical name, specifying only that they are in the chemical family of solvents. (However, interviews with some manufacturers' representatives indicated that two of the solvents used are dichlorobenzene and orthodichlorobenzene.)

No specific studies or tests on chemical grease-cleaning products have been published. Articles that do mention chemical drain cleaners are usually about biological additives and describe only the harm which chemicals pose to the natural sewer environment.

Chemical solvents are said to correct sewer blockages and prevent future blockages when applied regularly at maintenance dosages. These products are advertised as being biodegradable, emulsifiable, nonacid, and noncaustic. They reportedly eliminate regular grease-trap cleaning by dissolving soap, fat, oil, and detergents, restore soil absorption to drain fields, reduce or end the need for frequent septic tank or cesspool pumping, and control odors. The solvents may be successful in doing what they claim, but two important questions should be addressed: first, what effect do the chemicals have on sewer bacteria? Second, does the solvent actually dissolve the grease, or will grease just reappear farther down the sewer line or in the treatment plant? Finally, it is important to note that solvents will attack PVC sewer pipes, making application infeasible for systems that have this type of piping.

Bacterial Cultures. Commercial bacterial cultures are said to speed the digestion of proteins, carbohydrates, and fats in sewer lines, grease traps, and sewage treatment plants. Rarely can the naturally occurring bacteria in sewage degrade grease.

The breakdown of grease requires specific enzymes, which are produced by certain bacteria as they multiply and divide. The enzymes produced trigger the biological reduction of waste material present. The results of grease decomposition are either soluble or very finely divided products. Longer chain fatty acids are further broken down by the bacteria's enzymes. Enzymes are specific for the type of fat (or fatty acid) being degraded at a rate affected by temperature, salt content in the water, pH, and other environmental variables.

Bacterial cultures for grease removal can be divided into two types. The first is a liquid biological additive in which the bacteria are concentrated in a liquid suspension and do not become active until they have been introduced into a sewer line or grease trap that provides them with food (grease). Upon activation, they should degrade the grease. The liquid bacteria have a shelf life of 1 to 2 years, depending on storage conditions.

The second type of bacterial cultures are in dry or powder form. They are either air- or freeze-dried and do not become effective until they are mixed with water.

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[3] *Disposal of Waste Grease Generated From Dining Facilities.*

In addition to removing grease from grease traps and sewer lines bacterial additives are used effectively in sewage treatment plants to control sludge, scum, and odor. They unclog sewer lines, increase the digestive activity, break down and liquify grease, sludge, and other odor-producing deposits, and reduce the wastewater BOD. The bacterial cultures are safe for plumbing, septic tanks, and sewage treatment plants and they enhance biological activity.

Grease-consuming bacteria are cultured in large quantities as products for clearing grease-clogged sewer lines. Bacterial cultures are produced by giving a small number of suitable grease-eating bacteria an ample supply of grease and allowing them to reproduce. Food is then withheld for some time causing the weaker bacteria to die. After several cycles, a strong colony of bacteria is ready.[4] In wastewater, a mixture of different greases and organics must be treated; thus, several bacterial types are required. Most companies grow the bacteria in pure strains and then blend the various types together along with nutrients, wetting agents, and other ingredients. Some producers also add enzymes, thus making an enzyme-bacteria mixture.

Manufacturers of some biological additives claim the following is a list of benefits:

- Improving BOD_5 removal
- Increasing sludge's ability to settle
- Lowering sludge volume
- Eliminating grease mats
- Controlling malodors
- Reducing hydrogen sulfide corrosion
- Improving digestion of solids
- Improving digester operation
- Providing much quicker recovery from upsets due to shock loadings or mechanical failure
- Cleaning grease in collection systems
- Restoring percolation from fields and ponds.

These vendor claims may or may not prove accurate in all cases under scientific testing.

Enzymes. Enzymes are organic catalysts that speed chemical reactions when the correct environmental conditions such as pH, temperature, and salt content are suitable. Enzymes are proteins or proteins in combination with an inorganic or low-molecular-weight organic molecule. Like other catalysts, enzymes can speed reactions greatly without undergoing change.

Enzyme and enzyme/nutrient mixtures stimulate the metabolism of microorganisms, enabling bacteria to rapidly degrade grease and oil to carbon dioxide, water, and simple salts. One such mixture contains several agents from natural products that stimulate the multiplication and metabolism of microorganisms. The microorganisms depend on many factors.

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[4]N. Baig and E. M. Grenning, "Use of Bacteria to Reduce Clogging of Sewer Lines by Grease in Municipal Sewerage," *Biological Control of Water Pollution* (University of Pennsylvania Press, 1976).

Enzyme additive manufacturers claim their products are effective for the following purposes:

- Eliminating pumping of grease traps
- Eliminating odors
- Improving absorption capacity of cesspool drainage areas
- Opening organically plugged municipal sewer lines
- Improving the capacity of municipal sewage treatment plants
- Reclaiming lakes, streams, and other water bodies
- Deodorizing and restoring absorptive capacity to leach fields.

Again, these vendor claims are subject to bias so that prudence must be used when evaluating them. Appendix A lists some manufacturers of additives and chemical products on the market. (Product literature is available by writing directly to the manufacturer.)

Application of Cleaning Methods

Mechanical and Chemical Cleaning

Mechanical methods of sewer cleaning usually are used only after a sewer line has become blocked and has to be restored to service immediately. Some municipalities do use mechanical cleaning methods as part of regular maintenance, but this procedure is costly. To use a mechanical method such as a sewer rodder, cable machine, or water jet, an access port (e.g., a manhole or drain opening) must be available near the sewer clog. The machine is introduced through the opening and operated until the clog is reached and removed. The only mechanical cleaning method that would be suitable for cleaning grease traps is the vacuum machine. The vacuum hose would be inserted into the grease trap and the grease and organics would be vacuumed out.

As mentioned earlier, chemical cleaners such as acids and alkalis are restricted to acute drain problems. To apply, the correct dosage would be poured into the drain and left to clear the clog. These methods are used primarily in domestic plumbing--not commercially.

Chemical Solvents

Chemical solvents reportedly can be used for preventive maintenance both in grease traps and sewer lines. For approximately the first 2 weeks, large dosages of solvent are applied to the grease trap or sewer line to remove the accumulated deposits. After these deposits have been broken off, only a relatively small maintenance dosage will be applied a few times a week to prevent any new grease deposits from accumulating on the surfaces.

Biological Additives

The process of adding bacterial cultures to a system is termed "bioaugmentation." The bacteria, when added to grease traps or sewer lines, find an ample supply of grease and their population increases rapidly as the grease is consumed. Dominance of the supplemented organisms is obtained by applying high treatment dosages initially and then cutting down at prescribed time intervals until a nominal maintenance dosage would be applied thereafter. Some of the bacteria flow with the wastewater to the sewage treatment plant and remove excess grease there. For a few weeks after bacterial cultures are first applied, the treatment plant may become excessively overloaded with

grease and organics; this condition is due to the bacteria's breaking loose pieces of accumulated grease and organic deposits in the sewer mains which are then carried with the flow to the treatment plant.

When biological additives (including bacteria, enzymes, nutrients, and mixtures of the three) are used, care must be taken to ensure that no chemicals or other adverse conditions are present in the grease trap or sewer system that will inhibit or completely stop bacterial growth. To apply biological additives, the directions specified for each product should be followed. Dried bacterial cultures must be mixed with water before application and it is recommended that they soak for some time before application. It is also recommended that the bacterial cultures, whether liquid or slurry (made by mixing water with the dried bacteria), be brought to the approximate temperature of the wastewater to which it will be added to prevent thermal shock which would result in poor performance.

The cultures function best in warm temperatures and at neutral pH. Like solvents, the biological additives are added in large dosages for the first few weeks to break up the accumulated grease deposits. The amount of additive is gradually lessened to a minimal maintenance dosage which is applied a few times a week to prevent grease accumulation.

In treating gravity sewer mains and feeder lines, treatment is started at the lowest downstream trouble spot and then moved upstream in increments of 500 ft. If more than this length is treated, the accumulated grease that will slough off in large chunks initially may block the line. When treating a lift station, it is best to add the cultures to a manhole a short distance upstream from the lift station at the end of a pumping cycle or to sewer mains and laterals via manholes.

Biological additives have been suggested for use in grease interceptors to pretreat sewage. The additives are applied to grease interceptors in the same way as sewer lines, but application can be done automatically for some products (others cannot be added this way). Several automatic dosing machines are available from various manufacturers. The dispenser is attached to a drum of additives and feeds a precise amount to the grease interceptor at specific time intervals preset by the user. An automatic dispenser is practical for preventive maintenance in grease interceptors and specific sewer lines where this device can be used. A dispenser can preclude human negligence and error for cases in which additives can be introduced this way.

After most of the accumulated grease is removed from a sewer system, the bacterial colony population decreases because of the diminished food supply. A continued low dosage of biological additive is then necessary to keep the sewerage system free of future grease accumulations.

The information on biological additives suggested these products may have potential for use at military installations. Therefore, a more extensive review was conducted to collect data on laboratory and field testing. Chapter 4 describes these findings.

4 BIOLOGICAL ADDITIVES: TEST RESULTS

Laboratory Studies

Critics of the biological additives claim that controlled laboratory tests have yet to prove the effectiveness of these products.[5] This claim has some merit in that the literature on the subject of biological additive effectiveness is controversial. Several laboratory tests have shown no beneficial effects from using biological additives, concluding that these products do not work and that the naturally occurring bacteria will take care of any problems that develop.[6] Other studies report improvements attributed to the additives. However, no laboratory tests have been done specifically on grease degradation with biological additives; tests that have been done have focused on improvement of treatment plant performance. (Appendix B gives a procedure for testing these additives in the laboratory. Table 10 summarizes a survey of public and private sector groups using the additives.)

In one study,[7] concentrated bacteria and enzymes were evaluated based on the rate of BOD removal and the biological character of flocculants in the different systems. The substrates tested were a synthetic sewage, raw sewage, and industrial waste. Laboratory-scale aeration units were made from 1-gal jugs to simulate an activated sludge plant. Results of these tests indicated that the products neither increased the rate at which chemical equilibrium of a new activated sludge system was reached nor increased the rate of BOD removal. There was also no visual difference between flocculant of the natural system and that of the one with biological additives. Thus, it was concluded that as long as an activated sludge plant is designed and operated properly, biological additives will not increase plant efficiency.

In contrast, results of another study[8] showed that the additive stimulated microorganism growth with subsequent digestion of sewage. Oxygen uptake studies of

[5] "Bacteria Helps Clear the Air"; C. C. Larson, "1954 Operators Forum," *Sewage and Industrial Wastes*, Vol 27 (1955), p 612.

[6] W. N. Grune and R. Q. Sload, "Biocatalysts in Sludge Digestion," *Sewage and Industrial Wastes*, Vol 26 (1954), p 1425; H. Heukelekian and M. Berger, "Value of Culture and Enzyme Additions in Promoting Digestion," *Sewage and Industrial Wastes*, Vol 26 (1954), p 1162; J. E. McKee, et al., "Biocatalytic Additives in Waste Treatment," *Sewage and Industrial Wastes*, Vol 25 (1953), p 1268; R. E. McKinney and L. Poliakoff, "Biocatalysts and Waste Disposal II: Effects on Activated Sludge," *Sewage and Industrial Wastes*, Vol 25 (1953), p 1268; E. A. Pearson, et al., "Biocatalytic Additives in Sludge Digestion," *Sewage and Industrial Wastes*, Vol 29 (1957), p 1066; G. W. Reid and C. Imel, "Sewer Odor Studies," *Sewage and Industrial Wastes*, Vol 28 (1956), p 991; W. Rudolfs, "Enzymes and Sludge Digestion," *Sewage Works Journal*, Vol 4 (1932), p 782; L. Slote, *Development of Immobilized Enzyme Systems for Enhancement of Biological Waste Treatment Processes*, Report No. 5501-0113 (U.S. Environmental Protection Agency [USEPA], 1970); W. N. Wells and R. E. McKinney, "Plant-Scale Test of Biocatalyst on Sludge Digestion," *Sewage and Industrial Wastes*, Vol 27 (1955), p 871.

[7] R. E. McKinney and L. Poliakoff.

[8] I. Wojnowska-Barla, "Measuring the Effects of Biocatalytic Additives on Treatment Process Performance," *Journal of the Water Pollution Control Federation*, Vol 55 (November 1983), p 1374.

Table 10

Survey of Bacterial Additive Users

Names and Addresses	Population Served	Area	Total Length of Sewerage System	Type of System	Capacity	Comments
Ralph Shook Yorba Linda Water Dist.	2,500	N/A	N/A	Collect and transport to regional system	N/A	Bacterial cultures were used successfully to remove localized grease buildup.
[illegible] Cardener Water & Sewer Super. 80001 Ralston Road Arvada, CO 80002 (303) 424 6441	70,000	Arvada, CO	280 mi	Secondary with chlorination trickling filter with 2-stage digester	1 mgd	Symptoms indicating inefficient digester operation were: (1) inadequate production of methane; (2) 4 to 6 ft blanket in the digester; (3) sludge had excessive amounts of organic and volatile contents. Within 30 to 40 days, gas production doubled, and tripled in 60. Also, there was a tremendous improvement in the sludge.
Wayne Coloney, P.E. P.O. Drawer 3966 Tallahassee, FL 32303 [illegible] 385 8171	10,000	City of Perry, FL	20 to 30 mi	Primary	0.75 mgd dry day, 1.25 mgd wet day (badly infiltrated system)	This system operated at 28-30 percent BOD_5 and suspended soils (SS) removal. In the first year of bacteria use, BOD and SS removal increased to 50 to 70 percent the second year to 75 percent. A polishing pond increased this to 95 percent. Conventional treatment would have cost \$300,000 while the pond cost \$22,000 and \$200/month for bacteria.
[illegible] Tahoe City Public [illegible] Tahoe City, CA 95730 [illegible] 3796	25,000 average, 75,000 peak	Tahoe City, CA	City	Primary	3.5 mgd	This plant uses 1.5 lb bacterial culture per day, costing about 2.5 cents per million gallons. Tremendous decrease in odor, grease, solids, and BOD was observed.

Table 10 (Cont'd)

Names and Addresses	Population Served	Area	Total Length of Sewerage System	Type of System	Capacity	Comments
Russ Bond District Supt. Sanitation P.O. Box 1068 Santa Maria, CA 93454 (805) 925 1475	19,000	Laguna County	N/A	Secondary, filter	1.25 mgd	One pound of bacterial culture per day used in the Laguna City digester to remove grease and scum.
Paul Cygan, Chief Bureau of Sewers Dept. of Public Works City of Erie Erie, PA 16512 (814) 456 8561	180,000	Erie & outlying community	N/A	Activated sludge	65 mgd	Bacterial cultures used successfully for several years in cleanup of lift stations, scum wells and lines, skimmer lines, and primary and aeration tanks. Lift station energy requirements were reduced by factor of 3 and offensive odors eliminated.
Charles Caswell President Environ. Audit Corp 5100 Center Avenue Pittsburgh, PA 15232 (412) 682-1031	N/A	Chicago	N/A		0.108 mgd	Bacterial cultures used mainly to remove grease and industrial waste from oil tankers. Treatment was 1 lb every other day, gradually reduced to 1 lb every week. Prior to use, grease content was 200 to 300 ppm; after application, oil content dropped to 0 to 3 ppm.
W. F. Cochrane Trussville Sewage Treatment Plant	3,000	Trussville	N/A	Bowl filter	0.4 mgd	City's old filter was malfunctioning, with excessive fouling. Bacterial cultures added and significant improvement noted within 6 weeks, completely clearing in 13 weeks.

soluble organic compounds were done to determine the effects of biological additives. The laboratory study showed that biological additives produced a higher rate of oxygen uptake and increased the rate of organic compound removal.

Laboratory tests also have been done to determine the value of enzyme and/or bacterial cultures on the digestion of sewage solids.[9] The tests were done by adding the products to: (1) sterilized, (2) unsterilized, unseeded raw sludge, and (3) properly seeded ripe sludge and raw sludge mixtures. The additives were evaluated by their effects on supernatant BOD. The results of these experiments were negative; pure cultures of bacteria were not as efficient as the bacteria found naturally in sewage.

Others ran experiments with two laboratory-scale activated sludge units.[10] One unit acted as a control and the other was dosed with a biological additive. Biological kinetic coefficients were developed for the two systems. The Monod kinetics model from Metcalf and Eddy[11] was used to show the biological growth and substrate utilization (waste digestion rates by the bacteria). The reaction coefficients can show the effect of additives on a biological treatment system under different operating conditions. The results of these tests showed no significant difference in biological kinetic coefficients between control and dosed units. The unit dosed with the biological additive had a slightly higher overall bacterial growth rate and slightly greater calculated BOD removal efficiency than did the control unit. These researchers concluded that a biological additive has little effect on the overall performance of a correctly designed and operated activated sludge treatment plant. They also stated that if a plant were perhaps overloaded and operating with poor removal efficiency, an additive may help.

A few military installations have tested biological additives in their grease traps, sewer systems, and other areas of grease/oil accumulation. Field test results have varied, as seen in the following case studies.

Lessons Learned: Military Experience With Additives

Schofield Barracks, HI

The daily injection of 1 to 3 pt of an enzyme nutrient product in each of 20 grease traps at Schofield Barracks, Honolulu, HI, completely eliminated the need for mechanical pumping. The treatment proved to be cost effective and also eliminated the odor and cockroach problems.

This concentrated product appears to accelerate microbial metabolism, which results in a rapid natural breakdown of organic waste products. It is claimed to be nontoxic and, based on the Army's use over 1 year, the claim appears substantiated. Samples of the sewage plant effluent discharge have shown no evidence of product residue. In fact, effluent samples have indicated overall improvement in meeting Board of Health permit discharge requirements since introduction of the product into the

[9] H. Heukelekian and M. Berger.
[10] S. R. Quasim, et al., "Effect of a Bacterial Culture Product on Biological Kinetics," *Journal of the Water Pollution Control Federation*, Vol 54 (March 1982), p 255.
[11] L. Metcalf and H. P. Eddy, *Wastewater Engineering: Collection, Treatment, Disposal* (McGraw Hill, 1979).

grease interceptors. During initial tests conducted by the U.S. Army Support Command, Hawaii, and subsequent use over 1 year, the following benefits have been documented:

1. Waste grease collected in interceptors is totally digested, ending the pumping requirement and subsequent disposal problem.

2. Primary sewage lines are cleared of accumulated grease, eliminating blockage attributable to grease buildup. (Secondary and tertiary lines that have no enzyme product contact continue to have blockages.)

3. The cockroach and insect populations have decreased dramatically due to the elimination of grease interceptor wall deposits that harbor these pests.

4. Grease interceptor odors are gone.

5. Sewage treatment plant efficiency is improved to better meet effluent discharge requirements.

Especially notable is the elimination of odors normally associated with grease interceptors. Many of the Army dining facilities are colocated with billets. Odors emitted from the grease interceptors, especially the hydrogen sulfide and amines, had lowered the quality of life for service members living in the barracks. Daily complaints from building occupants were common and were especially acute during pumping operations. Since the introduction of the product, odors have been completely eliminated. Although a cost savings cannot be quantified for this benefit, the substantial improvement in living conditions for off-duty soldiers is considered paramount. Other cost/benefit data were calculated, however, and showed an overall monthly savings of just over $2000, making the additive cost-effective. Table 11 shows monthly costs with and without the additive.

The Army had first installed a system in July 1980 to apply a product in 20 grease interceptors located in dining facilities on Oahu. Due to the success at these installations, in terms of cost reduction, the product testing was expanded to 18 other facilities for a total of 38. The product is now used at the Tripler Army Medical Center (TAMC), all NAF activities, the Hale Koa Hotel, selected troublesome sewer lines at Schofield Barracks in the family housing area, and at the dining facilities previously indicated. Table 12 shows actual costs for treating the 20 grease interceptors in the dining facilities. Using the table to compare costs for annual maintenance and service calls before and after treatment, it can be seen that they were reduced by about 90 percent; total grease maintenance costs declined by nearly 40 percent.

Fort Leonard Wood, MO

Another field test was conducted at Fort Leonard Wood, MO, on a 1200-gal grease trap adjoining a mess hall (building 630). The test was started on June 8, 1983, after the grease trap had been pumped. A 4-gal purge application of the product was poured into the trap. The doser, which consisted of a peristaltic pump and a timer, was then activated. The injection pump was set to dose at a rate of 115 oz/day of a 1:3 solution of product and water. After 30 days (July 8), the doser was recalibrated to its daily maintenance injection of 58 oz/day of a 1:3 solution of product and water. On September 8, the grease trap was pumped to see if the additive was working. Upon pumping, it was seen that the grease trap was almost filled to the outlet port with garbage but there was no grease in the trap and no bad odor. The test was continued and the same results were found later.

Table 11

Monthly Cost Analysis for Schofield Barracks With and Without Enzyme Additive*

Cleaning Requirement	Cost Without Additive ($)**	Cost With Additive ($)***
Kitchen	19	0
Pumping	330	330
Emergency calls	3500	500
Odor control	520	0
Total cost/month	4545	830

Enzyme product cost = $2025
Total savings with additive - $2020/month

*Figures are based on an average of 1000-gal capacity grease trap system. Any additional benefits/savings accrued at the base sewage plant are not reflected (e.g., decrease in chlorine required for final treatment, pumps and lines upgraded to work at maximum efficiency).
**Before treatment--included mechanical methods and chemical additives; 1981 dollars.
***After treatment with enzyme product; 1981 dollars.

Table 12

Cost Comparison Between Standard Cleaning Practice and Enzyme/Nutrient-Based Additive (Schofield Barracks)*

Facility	Interceptors Number (Size, gal)	Additive Treatment Costs ($)	Annual Post-Treatment Maintenance Costs ($)	Cost of Pre-treatment Cleaning Methods ($)	Estimated Pretreatment Maintenance Service Call Costs ($)	Odor ($) Suppression
B Quad	3 (30)	3,180	744	1,476	5,760	-
C Quad	1 (250)	2,945	651	692	5,040	-
D Quad	1 (30)	1,338	651	792	5.040	-
E Quad	1 (30)	1,204	155	792	1,200	-
F Quad	2 (150)	6,527	1,085	1,188	8,400	-
	1 (100)	-	-	-	-	-
J Quad	1 (250)	3,347	1,007	792	7,800	6,240
3/4 th	1 (20)	3,012	310	1,080	2,400	-
Cav	1 (30)	-	-	-	-	-
NCOA	1 (20)	1,338	310	540	2,400	-
Co A	3 (30)	3,749	310	1,080	2,400	-
125th Sig Bn	2 (30)	1,673	310	1,476	2,400	-
Kahuku	1 (150)	2,008	155	1,080	1,200	
Hq Co	1 (30)	501	0	1,080	2,400	-
Totals	20 (1,150)	30,822	5,688**	12,168***	46,440+	6,240

*All costs are in 1981 dollars.
**Maintenance/service calls were reduced approximately 90 percent. Most service calls were related to mechanical blockages by rags, green pads, plastic bags, paper products, etc. Blockages reported as grease-related were in secondary and tertiary untreated sewer lines in the facility.
***Actual grease interceptor pumping costs represent approximately one third of additive treatment.
+Stoppages/maintenance costs vary at each installation based on the size of the interceptor, management practices of waste generators, and age of the facility. Available records [illegible] differentiate among service calls to dining facilities that reflect grease [illegible] problems. Data estimates were obtained through interviews, review of available records, and personal experience. Cost estimate ranges from a low of two 1 hr service calls/month to a high of 14 1 hr service calls/month. One-hour service calls averaged 6.3 [illegible]. Each service call was processed at $50 (two individuals @ $25/hr).

The Fort Leonard Wood DEH prepared a cost analysis for using this product to treat all 19 of the installation's grease traps versus pumping. The results are as follows:

1. Estimated cost to treat 19 grease traps for 1 year:

First year	$41,192/year
Second year	$31,698/year

2. Cost to pump 19 grease traps for 1 year:*

Labor (2 workers) (40 hr/wk)(2 wk to pump)(3 times/yr)	= 480 hr/yr
480 hr/yr x $15/hr	= $ 7,200/yr
Equipment rental 480 hr/yr x $9.76/hr	= $ 4,685/yr
Total cost	= $11,885/yr

As the cost analysis shows, it is much cheaper to pump the grease traps than to treat them with the product tested. The test results did indicate that the additive degrades grease and keeps grease traps clear of grease, but it does not degrade garbage. It should be noted that these results differ greatly from those in Hawaii.

USA John L. Page

The same product was used in the gray-water holding tank on the Beach Discharge Lander (BDL) USA John L. Page for controlling odors emitted from the deck vent pipe. The application was reported successful by crew members, with total elimination of foul odors. For approximately 90 days afterward, the vessel underwent cyclic dry dock maintenance and the walls of the gray-water holding tank were relatively clear of the encrusted residue normally found. The residue that did remain on the walls could be removed easily using a high-pressure hose. Normal untreated surfaces usually require manual chipping and scraping to remove encrusted material. Although this application was not evaluated for cost-effectiveness, enzyme-nutrient base additives may prove useful for wastewater holding tanks that have foul odors and other problems.

Discussion

Results from the documented laboratory and field tests clearly are inconsistent, as are the conclusions. Installations considering the biological additives should first analyze cost-effectiveness. However, as mentioned earlier, the cost data from installations has varied greatly. Thus, if individual facilities are to calculate cost-effectiveness in a way consistent with the others, standard procedures must be adopted. Chapter 5 recommends methods to be used uniformly by all installations in calculating cost/benefit data for cleaning sewage and treatment systems. A method for determining cost-effectiveness also is included. With this guidance, it will be possible to make realistic comparisons among installations. In cases for which the product appears to be cost effective, a laboratory analysis should be conducted to verify that consistent results are obtainable (see Appendix B).

*For the pumping cost estimate, three times/yr was used. At present, traps are pumped twice a year with satisfactory results.

5 PROCEDURES FOR COLLECTING COST DATA AND ANALYZING COST-EFFECTIVENESS

Table 13 shows the wide disparity among the services in reporting costs for maintenance of grease interceptors. Contributing to the variance are the frequency of pumping, difficulty in identifying service calls related to grease-related stoppages, and use of in house versus contract pumping. As a result, the cost-effectiveness of additives varies from one site to another. Because of these inconsistencies, it is important to calculate the total cost of current practices (i.e., pumpout, emergency calls) and compare this value with the total cost of using additives. Although the procedures described are for biological additives, other technologies could be evaluated by substituting appropriate data in the equations.

Estimating Grease Management Costs Without Biological Additives

Table 14 shows factors that contribute to the cost of removing grease and oil by conventional methods (no biological additives). Besides the number of pumpouts per year, other costs that must be considered are those for emergency calls to clear blocked sewer lines, insect control in mess halls, and unexpected business such as additional pumping at lift stations and charges from the wastewater treatment plant due to the grease and oil discharged. Table 14 should be reviewed to see which factors are relevant for a given installation.

In some areas, it may not be clear whether grease and oil are contributing to higher costs. In the sewage treatment plant, reduced digester capacity is not readily apparent. Also, the digester may break down only after long periods with high grease and oil loadings, so this cost would only appear in a long-term analysis. The best judgment will have to be made as to whether to include each factor in estimating costs when biological additives are not used.

The main components of the cost estimates are shown below. Equations for estimating costs for each component follow. In general, the estimated total annual cost of grease and oil management at an installation is:

Pumpout cost	+	Disposal cost	+	Cost for emergency line clearing	+	Cost of increased routine line clearing	+
[illegible]	+	Fumigation cost	+	Increased cost at lift stations	+	Charges from wastewater treatment plant.	

[illegible] would be totaled for the installation and analyzed for comparison with the [illegible] of using additives (see **Estimating Grease Management Costs With Biological Additives**). Whenever possible, local costs should be used for cost items such as [illegible] pumpout and disposal, emergency line clearing, and routine line cleaning.

Table 13

Cleaning Versus Treatment Costs at Representative Service Bases

Installation/ Base	Frequency of Pumping/Cleaning	Number of Interceptors	Current Costs ($)	Estimated Additive Treatment Maintenance Costs ($)
Wheeler AFB	Once/month	11	2,122*	20,080
Navy	Twice/month	28	144,396	51,114
MCAS (Kaneohe)	Weekly	12	9,516	21,906
Air Force	Weekly	17	19,509*	31,033
Army	Twice/month	38	122,142	69,369
Totals		106	297,675	193,503
Net annual savings				104,172

*Contract pumping only.

Table 14

Factors Contributing to Cost of Grease/Oil Removal at Army Installations

Grease Traps

Frequency of pumping
Number and size of traps
Pumping and disposal cost per trap
Odor control
Pest control

Sewer Lines and Appurtenances

Number of emergency pumpouts/clearings
Percent of sewer blockages attributable to grease and oil accumulation
Routine line flushing
Percent of line cleaning necessary due to grease and oil
Decreased pump capacity and reduced equipment life at lift stations
Manhole fumigation for pest control

Sewage Treatment Plant

Fines imposed for inability to meet oil/grease discharge limits
Additional manhours for grease/oil removal from screens, walls, etc.
Emergency calls to clear blocked lines within plant
Reduced equipment life
Reduced digester capacity
More frequent repairs on digester, pumps, other equipment

Pumpout Cost ($/yr)

Grease trap pumping often is contracted on a set schedule. Total annual installation cost for pumping would be:

$$\text{Pumpout cost (\$/yr)} = \frac{\text{Contractor cost(\$)}}{\text{Pumpout}} \times \text{No. traps} \times \frac{\text{No. Pumpouts}}{\text{Yr}} \qquad \text{[Eq 1]}$$

Pumpout costs for military installations have ranged from $15/trap to $132/trap (based on Table 13). Alternatively, pumping costs for grease traps can be estimated by using Equation 2:

$$\text{Pumpout cost (\$/yr)} = \frac{\text{Manhr}}{\text{Pumpout}} \times \frac{\$}{\text{Manhr}} + \frac{\text{Equipment hr}}{\text{Pumpout}} \times \frac{\$}{\text{Hr}}$$

$$\times \text{ No. Traps} \times \frac{\text{No. pumpouts}}{\text{Yr}} \qquad \text{[Eq 2]}$$

Disposal Cost ($/yr)

Disposal costs can be estimated using Equation 3:

$$\text{Disposal cost (\$/yr)} = \frac{\text{Disposal cost (\$)}}{\text{Pumpout}} \times \text{No. traps} \times \frac{\text{No. pumpouts}}{\text{Yr}} \qquad \text{[Eq 3]}$$

Cost of Emergency Line Clearing ($/yr)

Emergency line-clearing costs can be estimated using Equation 4:

$$\text{Emerg. line clear (\$/yr)} = \frac{\text{Manhr}}{\text{Call}} \times \frac{\$}{\text{Manhr}} + \frac{\text{Equipment hr}}{\text{Call}} \times \frac{\$}{\text{Hr}}$$

$$\times \frac{\text{Total no. calls}}{\text{Yr}} \times P \qquad \text{[Eq 4]}$$

where P = percentage of time expense incurred is due to grease/oil accumulation. The portion of emergency line clearings due to grease could be 80 to 90 percent. At Schofield Barracks (Table 11) emergency sewer line-clearing costs were reduced by 85 percent once additives were introduced into the system. Examine the records of emergency line-clearing calls and note the location of blockages to estimate the percentage due to grease accumulation.

Routine Sewer-Line Cleaning ($/yr)

The cost for routine sewer-line cleaning can be estimated from Equation 5:

$$\text{Routine line clean (\$/yr)} = \frac{\text{Cleaning cost (\$)}}{\text{Ft}} \times \frac{\text{Ft sewer cleaned}}{\text{Yr}} \times P \qquad \text{[Eq 5]}$$

where P represents the percentage of routine cleaning needed because of grease and oil accumulation.

Pest Control Cost ($/yr)

To estimate annual pest-control costs, use Equation 6:

$$\text{Pest control (\$/yr)} = \frac{\$}{\text{Application}} \times \frac{\text{Total no. applications}}{\text{Yr}} \times P \qquad \text{[Eq 6]}$$

Fumigation Cost ($/yr)

Fumigation costs can be estimated using Equation 7:

$$\text{Fumig. (\$/yr)} = \frac{\$}{\text{Fumigation}} \times \frac{\text{Total no. fumigations}}{\text{Yr}} \times P \qquad \text{[Eq 7]}$$

where P represents the percentage of fumigation costs incurred because of grease and oil problems (probably 1.0).

Increased Cost at Lift Stations and Other Appurtenances ($/yr)

These costs can be estimated from Equation 8:

$$\text{Lift station, etc. (\$/yr)} = \frac{\text{Additional required manhr}}{\text{Yr}} \times \frac{\$}{\text{Manhr}} + \frac{\text{Equipment hr}}{\text{Yr}} \times$$

$$\frac{\$}{\text{Hr}} \times \text{Capital recovery factor} \times \text{Parts replacement cost \$} + \text{Annual pumping cost (lift stations)} \times \text{\% increase due to grease/oil problems} \qquad \text{[Eq 8]}$$

At lift stations and wastewater treatment facilities, the additional costs would be for manhours and extra equipment for work on grease- and oil-related problems (e.g., grease removal from screens and walls). Parts replacements would be the best estimate of parts that would not otherwise be replaced (i.e., in the absence of grease and oil problems). The capital recovery factor spreads the large outlays for equipment over an arbitrary time period at a selected interest rate to obtain annual cost. The annual

pumping cost at lift stations could be estimated installation-wide or for an individual lift station. The cost is multiplied by a factor corresponding to the percentage of time grease/oil is believed to increase pumping cost (e.g., 10 to 20 percent).

Charges From Wastewater Treatment Plant ($/yr)

Any charges from the treatment plant because of grease/oil problems can be estimated using Equation 9:

$$\begin{aligned}\text{Plant chg. (\$/yr)} &= \frac{\text{Additional manhr}}{\text{Yr}} \times \frac{\$}{\text{Manhr}} + \frac{\text{Equipment hr}}{\text{Yr}} \times \frac{\$}{\text{Hr}} + \\ &\text{Emergency calls for line cleaning in plant (\$/yr)} + \text{Fines for violation of discharge limits on oil and grease (\$/yr)} + \text{Capital recovery factor} + \\ &\text{Parts replacement} + \text{Energy cost (\$/yr)} \times \text{Percent extra energy costs due to grease/oil problems} + \\ &\text{Cost of extra services (equipment etc.) due to equipment malfunction}\end{aligned} \qquad \text{[Eq 9]}$$

Some of the costs will be difficult to estimate because data are unavailable or the portion of actual costs attributable to grease and oil (P) is unknown. If these unknown costs are excluded and the estimate of total costs exceeds the estimated costs when biological additive treatment is used, then the test for cost-effectiveness of the biological additive will be conservative.

Estimating Grease Management Costs With Biological Additives

Table 15 lists factors contributing to the cost of grease management with biological additives. The total annual cost of grease management with biological additives is estimated by:

Product cost for traps + Feed system equipment and operation + Feed system maintenance +

Product cost for holding-tank application + Additional cost of grease-skimming at wastewater treatment plant.

Most of the information needed for the estimates will be supplied by the vendor of the biological additive being considered. Each factor is estimated as follows.

Table 15

Factors Contributing to Cost of Grease Management Using Biological Additives

Grease Traps

Number of traps
Number of meals served/day at each facility
Manufacturer's recommended dosage based on average no. meals served/day
Installed cost of feed facilities (including mixer, water lines, electric service)
Cost of replacement parts for feed system and frequency of replacement
Manhours required for system maintenance
Electricity to run product feed pump
Need for occasional pumpout

Sewer Facilities

Dosage in holding tanks
Number of holding tanks treated with additive

Sewage Treatment Plant

Additional manhours needed for possible increased grease skimmings

Product Cost ($/Yr)

The product cost is estimated using Equation 10, where n = the number of traps:

$$\text{Product cost (\$/yr)} = \sum_{i=1}^{n} \left(\frac{\text{Actual no. meals/day}}{\text{Std. no. meals/day}}\right) \times \frac{\text{Total amt. additive used per trap, gal}}{\text{Yr}} \times \text{Unit additive cost, \$/gal} \qquad \text{[Eq 10]}$$

The manufacturer of an additive under consideration will recommend a dosage rate for a grease trap, probably based on the number of meals served per day at the facility (standard number of meals). The total installation cost is found by adjusting by the actual number of meals served per day in each facility where the trap is located, with i = 1, 2, ... for n facilities.

The yearly total amount of additive needed must be summed using the application rate schedule (based on the standard number of meals served/day for a trap). The schedule probably will call for more frequent high dosages at first, followed by a lower maintenance dosage. These figures must be added to estimate the total annual supply for a trap serving a facility where the standard number of meals are served.

Installed Cost of Feed System and Operation and Maintenance ($/yr)

Equation 11 yields the installed cost of the feed system and operation and maintenance (O&M) costs:

$$\text{Feed System and O\&M (\$/yr)} = \text{No. traps} \times \text{Capital recovery factor} \times \text{Installed cost of feed system and parts} + \frac{\text{Manhr for feed system inspection, maintenance}}{\text{Yr}} \times \frac{\$}{\text{Manhr}} \qquad \text{[Eq 11]}$$

The manufacturer should estimate the installed cost of the feed system, including storage tank, water lines, electrical lines, pumps, and mixer, and annual electricity costs for operating the system; this estimate will vary among products. The installed feed system costs are multiplied by a capital recovery factor to obtain annual cost. For a 20-year life at 8 percent interest, the factor is 0.10185. The product representative also should be able to indicate the amount of time needed for normal feed system maintenance. Equation 11 assumes that costs for equipment, electricity, inspection, and maintenance are independent of the number of meals served per day.

Holding Tank Application ($/yr)

The cost for additive applied to holding tanks is (Equation 12):

$$\text{Holding tank add. cost (\&/yr)} = \frac{\text{Total annual additive dose (gal or lb/yr)}}{\text{Holding tank}} \times \text{No. holding Tanks} \times \frac{\text{Additive unit cost (\$)}}{\text{lb or gal}} \qquad \text{[Eq 12]}$$

Additional Cost of Grease Skimming at Wastewater Treatment Plant ($/yr)

Equation 13 can be used to estimate this cost:

$$\text{Grease-skimming cost (\$/yr)} = \frac{\text{Additional manhr for grease-skimming}}{\text{Yr}} \times \frac{\$}{\text{Manhr}} \qquad \text{[Eq 13]}$$

This cost may not be incurred at all installations. At Chanute AFB, IL, one additional manhr/day was necessary to manually skim grease from the surface of the IMHOFF tank. This additional time resulted from using a biological additive in 10 grease traps.

Estimating Cost-Effectiveness of Additives

After the annual costs for grease management using (1) conventional methods and (2) biological additives are estimated, the two values are then compared. Treatment with biological additives will not be cost-effective at all installations, so it is important to estimate the cost of each alternative using sound judgment and the best information available.

The methods described in this chapter were used to analyze the cost effectiveness of additives used at several military installations, including Schofield Barracks.

Hickam Air Force Base (AFB), HI

Grease interceptors at Hickam AFB are pumped and cleaned weekly by the Public Works Center (PWC), Pearl Harbor. Data furnished by PWC are as follow:

- Estimated pumping/cleaning time per call (includes driving time) = 0.5 hr
- Total number of traps serviced = 17
- Number of personnel = 2
- Cost/manhr, driver = $21.40
- Cost/manhr, assistant = $19.92
- Truck cost/hr = $2.82.

The formula for annual cost is:

$$[(\$2.82 + \$21.40 + \$19.92)17]\,[0.5(52)] = \$19{,}509$$

Note that the cost reported for the truck is only $2.82/hr; although verified by PWC, the cost appears extremely low. Data obtained from USASCH indicates that current operational cost for a 1000-gal tank truck with pump is $36.40/hr. Using $36.40/hr for the truck, the annual pumping cost would be $34,352 versus $19,509. Using the higher figure, treatment with biological additives would be cost-effective. Blockage/service calls were not reported due to the difficulty in identifying precise plumbing problems.

Wheeler AFB

Wheeler currently contracts monthly pumping of the 11 traps at a cost of $16/trap. No other maintenance cost was identified; however, USASCH reports that a substantial amount of lipid waste is entering the sewage treatment plant from Wheeler, requiring treatment with additives at the plant at an annual cost of approximately $7000. Other maintenance costs were not reported.

Marine Corps Air Station (MCAS), Kaneoke, HI

A lump sum figure of $9516 was reported which includes pumping, disposal, and maintenance associated with 12 traps. It was also reported that some of the waste grease collected in the traps was discharged into sewer lines. Based on the costs reported by other services, stoppages were not included as part of the annual maintenance cost. If all costs were reported, treatment with additives does not appear cost-effective for the MCAS.

Navy

In an unpublished cost study by the Navy, an estimated 192 manhours annual maintenance was reported per grease interceptor. Manhour costs were reported at $26.86 + ($192 x $26.86)(28) = $144,396.

By extrapolating PWC charges to the Air Force for pumping only, annual maintenance cost (stoppages/service calls) can be estimated at approximately $100,000 or $3500/trap/year. This figure translates to 5.8 service calls/month/trap and closely parallels the Army experience of 6.3.

Army (Including Schofield Barracks)

Based on a telephone survey with several facilities, annual treatment and maintenance costs for the Army averaged $1541.10 and $284.40, respectively, per trap per year. Although treatment cost will vary based on the trap size and flow volume, the average cost to the Army was used to approximate treatment costs for all services. The formula is:

$$(a + b)c = d$$

where a = annual additive cost/trap ($1541.10), b = annual maintenance cost/trap ($284.40), c = number of traps, d = sum of annual treatment and maintenance costs. Using Equation 13:

$$(\$1541.10 + \$284.40)106 = \$193,503$$

The study at Schofield barracks proved to be cost-effective (Table 10), but as Table 13 shows, of the six installations/bases listed, only three could use additives cost effectively. The other three would pay considerably more to treat with an additive than they are spending at present to clean and maintain.

Clearly, cost-effectiveness varies greatly. *However, it should be the first consideration in any decision-making process for use of biological additives.*

6 CONCLUSIONS AND RECOMMENDATIONS

Expenses for grease and oil control and removal at military installations are high. Over two-thirds of the installations responding to a survey reported having problems related to grease and oil: accumulation in traps, sewer line blockages, fouling of sewage pumping facilities, and interference with wastewater treatment processes.

The usual mechanical methods of removing grease and oil (e.g., pumping out grease traps, clearing sewer lines) are labor-intensive and prevent neither grease and oil accumulation nor the undesirable side effects of foul odors and insect infestations. Chemical cleaners (usually strong acids or alkalis) are effective for unblocking local household drains, but should not be used on a wide scale for commercial sewage systems due to their high cost and potential danger to treatment plant workers and the environment.

Other methods of controlling and removing grease and oil accumulation have been reviewed to identify alternatives to mechanical and chemical cleaning. Biological additives such as bacterial cultures and enzymes have shown promise at some test sites. These additives provide enzymes that digest specific types of fats and fatty acid chains and are claimed to be nontoxic and nonpolluting. However, documented laboratory and field testing of these products have revealed inconsistent results. Even the military's limited experience with these additives has been inconclusive, which is partly due to nonstandard cost reporting procedures.

Because of the scant information available on the effectiveness of biological additives as well as contradictory claims and the lack of reliable scientific testing, installation managers are cautioned to use prudence in deciding whether to use biological additives. The decision to use these products must be made on a case-by-case basis and the first consideration should be cost-effectiveness. (In some cases, it may be more economical to continue using mechanical methods.) Procedures are described for calculating costs associated with grease control/removal and for determining the cost-effectiveness of using additives.

Even if additives appear to be cost-effective, it is recommended that various additives be evaluated in light of scientific evidence rather than vendor claims and testimonials. Some products simply may not be effective at controlling grease using normal dosages; therefore, the product cost may increase substantially with higher dosage rates.

METRIC CONVERSION FACTORS

1 gal = 3.8 L

1 oz = 28.35 g

1 lb = 0.45 kg

1 ft = 0.305 m

$^{\circ}F = (^{\circ}C \times 1.8) + 32$

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APPENDIX A:
BIOLOGICAL ADDITIVES: MANUFACTURERS AND PRODUCTS

Table A1 lists a representative sample of manufacturers and their products. Readers wishing to obtain product literature should write directly to the manufacturer.

Table A1

Biological and Chemical Additive Manufacturers and Products*

Product Name	Manufacturer	Classification	Cost
Manzyme	Mantek P.O. Box 222263 Dallas, TX 75222 214-438-0361	(Powdered) Enzyme, bacteria and nutrient mixture	Approx. 100 lb, $10/lb; case of 12 1-lb containers, $18.40/lb
CYTX-6C	Ploybac Corp. 954 Macron Blvd. Allentown, PA 18103 215-264-8740	(Liquid) Enzyme and bacteria mixture	Not available
CYTX-5	Ploybac Corp. 954 Macron Blvd. Allentown, PA 18103 215-264-8740	(Powdered) Enzyme and bacteria mixture	Not available
Bactozyme	Oxford Chemicals Box 80202 Atlanta, GA 30366 404-452-1100	(Powdered) Enzyme and bacteria mixture	25 lb, $15.10/lb 50 lb, $14.05/lb 100 lb, $13.70/lb 200 lb, $13.35/lb 300 lb, $12.40/lb
Shur go	HI BAR Ltd. 1825 Kusel Rd. Oroville, CA 95965 916 534 7603	(Liquid) Enzymes, wetting agents and micro-nutrients	Approx. $27/gal
Enzymes 300	Share Corporation P.O. Box 23053 Milwaukee, WI 53225 414-355-4000	(Powdered) Enzymes, bacteria, vitamins, minerals, and amino acids	Not available

*This list is not all inclusive and listing of any product or manufacturer does not constitute endorsement by the U.S. Department of the Army. Costs are in 1985 dollars.

Table A1 (Cont'd)

Product Name	Manufacturer	Classification	Cost
Liquid Live Microorganisms	General Environmental Science P.O. Box 22294 Beachwood, OH 44122 216-795-4733	(Liquid) Bacteria	Approx. $16/gal
Bi-Chem TD-500L	Sybron Biochemical Box 808 Salem, VA 24153 703-389-9361	(Liquid) Mutant bacteria	1-99 gal, $12/gal; 100 gal, $10.50/gal; 55-gal drum, $10.30/gal
DBC Plus Type A	Flow Laboratories, Inc. Environmental Cultures Division 828 W. Hillcrest Blvd. Inglewood, CA 90301 213-641-7722	(Powdered) Bacteria	25 lb, $10.50/lb 100 lb, $9.95/lb 100 lb, $9.05/lb
Liquid Chem-zyme	National Chemsearch 2727 Chemsearch Blvd. Irving, TX 75062 201-329-8111	(Liquid) Enzymes and bacteria	55-gal drum, $14.40/gal
Oxford Sanfax XL-222	Oxford Chemicals, Inc. Box 80202 Atlanta, GA 30366 404-452-1100	(Pelletized) Alkali (sodium hydroxide)	Not available
Oxford Oxo-Solv	Oxford Chemicals, Inc. Box 8020 Atlanta, GA 30366 404-452-1110	(Liquid) Solvent	55 gal, $13.85/gal; 35 gal, $13.85/gal.
Greastrol	Cloroben Chemical Corp 1035 Belleville Tpk. Kearney, NJ 07032 800-631-9550	(Liquid) Solvent (dichloro- benzenes)	55-gal drum Approx. $16.36/gal
Greastrol 2	Cloroben Chemical Corp. 1035 Belleville Tpk. Kearney, NJ 07032 800-631-9550	(Liquid) Solvent	55-gal drum Approx. $16.36/gal

APPENDIX B:

LABORATORY TEST FOR PERCENTAGE DEGRADATION OF GREASE

This test is a simple way to conduct a bench analysis of any biological additive being considered for use in grease removal.

Equipment and Materials

1. Grease sample to be degraded
2. Beaker, 50 ml
3. Pasteur pipet
4. Pipet, 2 by 1 ml
5. Erlenmeyer flask, 3 by 125 ml
6. Three No. 15 3-hole stoppers
7. Air source
8. Miniature airline aquarium tubing
9. Two dilution blanks
10. Distilled water
11. Drying oven, 105°C
12. Desiccator
13. Ammonium nitrate
14. Potassium phosphate
15. Bacterial formulation to be evaluated.

Procedure

1. Pour (or place) approximately 15 to 20 ml (15 to 20 g) of the grease into a 50-ml beaker and place into the 105°C drying oven for 3 days.

2. Label two Erlenmeyer flasks with the laboratory number of the grease sample and either "C" or "Bacterial formulation."

3. Place the labeled flasks into the drying oven at least 1 day before the end of the 3-day period described in Step 1.

4. After the 3 days prescribed in Step 1, place the desiccated oil and flasks into the desiccator and allow to cool (usually 1 hr).

5. Place 1 g bacterial formulation into a water blank, shake, and set aside to soak.

6. Using the analytical balance, weight the Erlenmeyer flask marked "C" and record the weight. Adjust the dials on the balance to show a weight of 2 g higher. Add the desiccated oil, using a Pasteur pipet, to reach as close as possible the 2-g increase. Record the actual weight. Repeat for the other flask.

7. Add 0.1 g ammonium nitrate and 0.1 g potassium phosphate to each flask from Step 6.

8. Fill each Erlenmeyer flask with distilled water to the 100-ml graduation.

9. Place 0.5 ml bacterial formulation from Step 5 into the Erlenmeyer flask marked "Bacterial formulation."

10. Open two of the three holes in each stopper and place a stopper in each flask.

11. For each flask, slip an airline through one hole of the stopper and down to the bottom of the flask. Attach and free end to the air source and adjust the airflow to provide medium to heavy mixing/aeration.

12. Aerate at room temperature for 30 days. Replace the water lost through evaporation on a daily basis by filling to 100-ml mark.

13. At the end of 30 days, remove the stoppers and hoses. Place the flasks into the 105°C oven for 24 days.

14. After 24 hr of drying, place the flasks into the desiccator to cool.

15. Weigh each flask using the analytical balance.

16. Calculate the percentage degradation of the oil/grease for each flask:

$$\%\ \text{degradation} = \frac{(\text{Wt. of flask + oil, initial}) - (\text{Wt. of flask + oil, final})}{(\text{Wt. of flask + oil, initial}) - (\text{Wt. of flask})} \times 100 \qquad \text{[Eq B1]}$$

17. Be sure to report if an emulsion occurs during the 30 days of aeration.

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